JPRS: 3868

13 September 1960

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U. S. JOINT PUBLICATIONS RESEARCH SERVICE
205 EAST 42nd STREET, SUITE 300
NEW YORK 17, N. Y.

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JPRS: 3868

CSO: 4155-D

THE EFFECTIVENESS OF USING NATURAL GAS IN THE CEMENT INDUSTRY OF THE USSR

/Following is a translation of an article by I. Ya. Furman and L. I. Lapina in the Russian-language periodical Gazovaya Promyshlennost' (The Gas Industry), Vol. 5, No. 6, June 1960, pages 35-39/

In determining the economic effectiveness of the use of natural gas in the national economy, it is necessary to take into account not only the more favorable technical and economic indicators of the production and transportation of gas in comparison with other forms of fuel, but also the supplementary effect that may be obtained for users of natural gas wit the replacement of solid or liquid fuel by gas.

One of the largest of such consumers of gas as an industrial fuel is the cement industry.

In 1958, the cement industry of the country used 1.6 billion m^3 of gas. According to the Leningrad Giprotsement Institute, about 11 billion m^3 of gas is to be used at cement plants in 1965 (Table 1).

According to preliminary calculations, bu 1970 the gas consumption of cement plants should rise to 18 billion m^3, bringing the share of gas in the fuel balance of the cement industry to 91%.

The principal indicators determining the effectiveness of the use of natural gas in the furnaces of the cement industry are:

-- reduction of the fuel component of cement cost as a result of lower gas cost, elimination of fuel-storage and fuel-preparation costs and also reduction of relative fuel consumption;

-- reduction of relative electric-power costs and auxiliary-materials costs, reduction of furnace-lining expenses;

-- reduction of capital investment in the building of new plants and reduction in the number of personnel;

-- improvement of cement quality.

Table 1. Share of gas in the total fuel consumption of cement plants, by economic regions of the country, for 1965.

	Total fuel consumption, thousand t "standard" fuel	Gas consumption thousand t "standard" fuel	Share of gas in total fuel consumption
North	281	88	31.3
Northwest	561	199	35.5
Center	2854	2541	89.0
Volga region	1595	1595	100.0
Northern Causcasus	955	955	100.0
Urals	2232	2232	100.0
Western Siberia	1314	--	--
Eastern Siberia	1082	--	--
Far East	662	--	--
Central Asia and Kazakhstan	1417	1133	80.0
Transcaucasia	844	844	100.0
South	2692	2692	100.0
West	709	709	100.0
Total	17198	12988	76.6

-- Reduction of the fuel component of cement cost. Fuel occupies a considerable place in the cement cost structure -- over 25%, and in the cost structure of cement clinker, almost 40%. Therefore the alteration in the fuel component resulting from a changeover of cement plants to gas has a considerable effect on the change in cement cost as a whole. This change can be brought about by:

-- reduction in fuel cost;

-- reduction in the expenses of fuel storage and of preparing it for combustion;

-- reduction in relative fuel consumption.

-- Reduction in fuel cost. It should be noted that industrial establishments, including cement plants, account for fuel on the basis of retail prices. Solid fuel is accounted for on the basis

of retail price FOB - station of origin plus the railroad charges for its transportation, and natural gas is accounted for on the basis of delivered price.

It is well known that between the cost of solid fuel and its retail price, the difference is small -- 3-5%. Not so with natural gas. Here, between the cost of its production and transportation even over very long distances (1,000 -1,500 km) and its retail price, a considerable gap exists. Therefore for determining the effectiveness, from the point of view of the national economy, of the replacement of solid fuel by natural gas it is necessary to carry out the calculations not on the basis of retail prices, but with account taken of the actual cost to the national economy, i.e., on the basis of the production cost of fuel.

Calculations carried out on the basis of the prospective plan for 1965 have shown that, taking into account the indicators of coal transportation and gas supply to cement plants in various economic regions of the country, the fuel component of clinker cost will change in the following manner (in%).

Northwest	-- 28.4	Northern Caucasus	-- 34.0
West	-- 30.0	Transcaucasia	-- 34.3
Center	-- 30.1	Urals	-- 26.6
South	-- 31.3	Central Asia and	
Volga region	-- 33.5	Kayekhstan	-- 30.3

-- Change in the relative consumption of fuel and electric power. At cement plants which burn solid fuel, relative fuel consumption includes consumption of fuel directly for roasting the clinker in the furnace, and heat losses for the drying of coal in coal mills (na ugol'nykh mel'nitsakh) and in drums.

With a changeover to gas, fuel expenditures for coal drying are eliminated. Fuel losses in unloading and storage also disappear. The replacement of coal by gas permits a saving of up to 5% in fuel. This is also confirmed by a comparison of accounting data for plants operating on gas and on coal.

With the replacement of coal by gas, relative electric-power consumption at the plants decreases, since the necessity of power expenditure for coal grinding is eliminated.

-- Increased furnace productivity. The first experiments in the conversion of cement-industry furnaces to gas showed that the indicator for furnace utilization over time is thereby improved. This was noted already in 1938, after the conversion to gas of the Baku cement plants /3/, as well as in a number of other, later works /2, 3/.

Analysis of the calender-time utilization indicators for a number of plants in recent years has disclosed that, whereas with rare exceptions the utilization coefficient for plants operating on coal comprised 80-85%, for plants utilizing natural gas this coefficient has in recent years been reaching 95-96%.

The principal reason for the augmentation of rotating-furnace productivity in a considerable increase in the durability of their lining upon conversion to gas operations; this is explained by the more uniform and stable technological regimen, and by the lack of needs for forced operation of the furnaces. With the operation of cement plants on gas, time spent on furnace repair is reduced.

The more rhythmic operation of plants operating on gas is a factor under lying the higher indicators of extensive furnace-productivity utilization at these plants. It is possible, for example, to compare the indicators of rhythmic operation of the Belgorod plant, operating on gas, those of the Karaganda plant which utilizes solid fuel (Table 2.)

Table 2. Indicators of rhythmic operation of the Belgorod and the Karaganda plants for 1958

	Type of fuel used	Uninterrupted operation, 24-hr periods	Operated with standstills of total duration, in hr, of				All-day stoppages, 24-hr periods
			1 and less	1 to 4	4 to 8	over 8	
Belgorod	gas	270	23	15	12	17	22
Karaganda	coal	185	69	44	25	26	37

To confirm the conclusions presented above with regard to alteration of the technical and economic indicators of the work of cement plants upon their conversion to gas, Figure 3 shows work indicators of plants equipped with 150-meter revolving furnaces of the same tupe, account being taken of the fact that some of these plants operate on coal, and some on gas /4/.

Table 3. Technical and economic indicators of the work of plants equipped with 150-meter furnaces.

	Fuel consumption for clinker roasting kg standard fuel/t*	Electric power consumption, kwh/t cement	Coefficient of calender-time utilization	Lining durability in clinkering zone, days
Average for plants operating on gas	260	82	93.7	137.7
Average for plants operating on coal	271	89	83.9	53.3
Relationship of indicators, %	-4.2	-8.0	+11.7	

*For comparability, fuel consumption is recalculated for equal 40% moisture content of the roasted material (slurry /shlam/).

-- Reduction of capital investments in new plants, planned to work on gas fuel. Various types of planning materials evaluate the reduction of capital investment in different ways; on the average it amounts to 5-10%, which can be seen from the data shown in Table 4.

Table 4. Relative capital investments in cement plants for operation on coal and on gas.

(according to materials of planning organizations*)

	Relative capital investments, ruble/t cement		Reduction of relative capital investments, %
	For operation on coal	For operation on gas	
Planning assignment for increasing capacity of Begovat plant	223.4	214.4	4.1

Planning assignment for conversion of Kuvasay plant to gas fuel	210.0	190.0	10.0
Standard plan of plant with 2 furnaces, each 170 x 4.5 m	280	266	5.0
Standard plan of plant with 2 furnaces, each 185 x 5.0 m	210.0	190.0	10.0

*According to materials of the planning organizations Giprotsement (Stalingrad), Sevkavgiprostroyprom (Novorossiysk), and according to the date of the NII Tsement/Scientific Research Institute for Cement/.

The reduction in capital investment with operation on gas is connected with the fact that in this case the following structures and equipment are no longer necessary: coal-storage facilities, coal-crushing and -transport department, fuel-drying and grinding department. Instead, the necessity arises for the following, considerably less capital-intensive structures: branch gas line to plant, GPS / gazoprovodnaya set' -- gas-line network(?), and intraplant networks.

Reduction of the volume of capital investments leads to a reduction also in the cost of cement, since the amortization component is reduced. In the case even of currently operating plants which have been converted from coal to gas mortization is not charged to idle equipment connected with the combustion of solid fuel, and operating costs are thus reduced.

With the conversion of plants to gas fuel, their operating staffs are reduced in number. On the basis of accounting data and the various planning materials presented above, this reduction is estimated at 4-5%.

The numerical reduction of personnel in the replacement of coal by gas at cement plants leads, along with a number of other factors, to an increase in labor productivity and to a reduction in relative labor costs for the production of cement. A comparison of labor costs for the production of cement in 1958, at plants employing various types of fuel (equipped with 150-meter furnaces), confirms this assertion.

Number of man-hours expaned by workers per ton of cement

	1957	1958
At plants operating on coal	3.7	2.8
At plants operating on gas	2.1	1.9

-- Improvement of product quality. It is well known that the principal indicator of cement quality is its average grade /srednyaya marka/. Cement grade is determined on the basis of the results of compression and rupture tests, performed upon samples prepared in accordance with the GOST /State Bureau of Standards/.

It should be borne in mind that cement grade depends, in addition to the type of fuel used, also upon the composition of the admixtures. Therefore it will be more correct to link the type of fuel burned to the average grade of clinker.

We have analyzed the clinker-quality indicators for two Novorossiysk plants -- the "Proletariy" and the "Oktyabr'" -- for the 1954-1959 period. It is well known that these plants were converted in the early part of 1956 from solid fuel to gas. There is thus available an opportunity of tracing variation in the clinker grade after conversion of the furnaces to gas. Table 5 shows the cement-quality indicators at these plants for the indicated years, with the exception of 1956 when conversion of the plants to gas took place.

It can be seen from Table 5 that the average clinker grade increased considerably in the most recent years. Analysis of the monthly clinker-quality indicators at these plants has shown that, whereas before conversion to gas the yield of "400"-grade clinker was a fairly frequent occurrence (and in a number of cases clinker of even lower grades was obtained), with operation on gas fuel the clinker has an average grade of not less than "550", and in a number of cases a grade of "600" and even "700".

Table 5. Clinker-quality indicators at the "Oktyabr'" and "Proletariy" plants for the 1954-1959 period.

	Rupture strength, kg/cm^2			Compression strength, kg/cm^2		
	Duration of hardening, days					
"Oktyabr'" Plant						
1954	20.2	22.6	27.1	400	466	552
1955	20.9	23.1	27.9	385	450	531
1957	29.0	30.4	33.4	428	510	587
1958	31.2	32.7	35.9	472	570	648
1959	31.5	32.9	36.2	489	590	671
(I half-year)						
"Proletariy" Plant						
1954	25.0	26.1	28.7	384	438	522
1955	22.7	23.7	26.1	355	--	471
1957	28.9	30.2	33.2	379	455	555
1958	31.2	33.4	35.3	349	399	600
1959	28.1	30.3	32.1	388	481	591
(I half-year)						

The increase in clinker quality with the replacement of solid fuel by gas correspondingly leads to an increase in the quality of cement, although, as has already been indicated above, a part is played here by other factors as well, in particular by the nature of the admixture included in the composition of the cement.

The comparisons presented above referred to the replacement of solid fuel by natural gas. With respect to the replacement, at cement plants, of liquid fuel by natural gas, two question groups may be noted:

-- comparison of the technical and economic indicators of furnace operation on gas and on mazut;

-- comparison of the cost indicators of oil and of mazut.

With respect to improvement of the technical and economic indicators of revolving-furnace operation upon the conversion thereof from liquid fuel to natural gas, no unanimous opinion has as yet been formed.

According to the indicators of tests carried out at the Baku cement plant, with conversion from mazut to gas the productivity of furnaces increased approximately by 6%, and full consumption, on the contrary, rose 1.5%-2% /1, 2/.

According to the data of the Vol'sk cement plant "Bol'shevik," converted from liquid fuel to gas in 1958, the hourly productivity of furnaces, their coefficient of utilization, the relative fuel consumption, and the clinker quality remained unchanged as a result of the conversion from mazut to gas. According to the data of the other Vol'sk plant "Komsomolets," with conversion of the furnaces from liquid fuel to gas their hourly productivity rose 1.5-2%, their coefficient of utilization remained unchanged, and the relative fuel consumption increased 3-4%.

Analysis of accounting data for the other plant belonging to the Vol'sk group also precludes the formation of any definite conclusions. At the present time it can only be noted that the conversion of cement plants from mazut to gas leads to no significant changes in the technical and economic indicators of their operation. It is true that the cost of mazut facilities at plants is somewhat higher than that of intraplant gas networks and GRP's; however, this circumstance has little effect on the cost of cement production and on relative capital investments for this purpose.

With regard to alteration of the fuel cost as a result of the replacement of mazut by gas, not in all regions is gas cheaper than mazut. In some regions the cost of liquid fuel is lower than that of gas.

With respect to the use of polysulfide mazuts at cement plants, the principal drawback lies in the following. As is well known, a plant with a capacity of 500-600 thousand tons of cement per year will require approximately 100 thousand tons mazut per year. Without preliminary desulfurization, the combustion of such a quantity of polysulfide mazuts is inadmissible from the point of view of sanitation and hygiene, since it pollutes the air with sulfur compounds. Depending on the purification method, outlays for purifying industrial smoke gases of sulfur compounds vary per ton of "standard" fuel for installations consuming 100 thousand tons of mazut per year, from 73 to 180 rubles in terms of capital investment, and from 18 to 55 rubles in terms of operating costs.

With these considerations taken into account the combustion of high-sulfur mazuts already becomes considerably less economical than the use, at cement plants, of natural gas.

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